

## **REMARKS**

Applicants have now had an opportunity to carefully consider the Examiner's comments set forth in the Office Action of December 23, 2009. Applicants file herewith a petition for a one month extension of time for filing a response to the office action. Claims 1, 3-6, 8-28 and 46-48 are pending in the application. Claims 1, 3-6, 8-28 and 46-48 stand finally rejected.

### **Interview Summary**

Applicants wish to thank the Examiner and the Examiner's Supervisor for the courtesies extended to Applicants' representatives during a telephone interview conducted on April 7, 2010. During the Interview, Applicants' representatives discussed the references currently cited against the pending claims. Applicants' expert, Mr. James Stiles, explained why the phosphor disclosed in Yano cannot be substituted for the phosphor disclosed in Takahashi, due to the chemical thermodynamics and kinetics of the two materials and the reaction of with fluoride. The argument provided is set forth in full below. Further, Applicants note that on the advice of the Examiner no amendment is being filed as part of this Response, but rather a statement supporting Applicants' position that a *prima facie* case for obviousness has not been established by the current combination of references.

### **The Office Action**

All claims stand finally rejected under 35 U.S.C. 103(a) as being unpatentable over the combination of Takehashi et al. (U.S. Patent No. 5,142,192) and Yano et al. (U.S. Patent No. 6,699,596). More specifically, the Examiner has taken the following position:

1. The primary reference (Takahashi et al) sets forth a listing of insulating layer materials, including therein calcium fluoride ( $\text{CaF}_2$ ) and magnesium fluoride ( $\text{MgF}_2$ ), for use with a luminous layer which may comprise  $\text{SrS:Ce}$ . The Examiner acknowledges that Takahashi fails to disclose the use of a rare earth metal activated barium thioaluminate or magnesium barium thioaluminate.

2. The secondary reference (Yano) sets forth a similar listing of insulating materials, but does not disclose the use of the fluoride materials, for use with a barium thioaluminate or magnesium barium thioaluminate phosphor, and also suggests that SrS:Ce may be used, though it has a short luminance and the barium thioaluminate phosphor is an improvement.
3. The Examiner then assumes that, based on the potential use of a common phosphor, the groups of insulating layers should be considered to be interchangeable, thus arriving at the use of a fluoride-containing insulating layer with a barium thioaluminate phosphor.

Applicants traverse.

**Remaining Claims Are Distinguished From the Cited Art**

Having reviewed the Examiner's position, and the art, Applicants wish to point out the disparity and patentable distinction between the teachings of the cited references, whether taken alone or in combination, and the invention as currently claimed. Applicants maintain their position, as set forth in their last response dated September 30, 2009, and as set forth during the Interview referred to above, which is summarized herein. The foregoing together establish that the references fail to realize and teach the invention which is the subject hereof.

The current independent claims, and therefore all claims depending therefrom, recite a structure having a fluoride-containing layer positioned directly adjacent and in contact with the upper and/or lower surfaces of the blue emitting phosphor thin film layer such that fluoride is partially infused into the phosphor layer but without any adverse effect on the luminosity of the phosphor. The primary reference fails completely to teach a blue light emitting phosphor layer comprising the claimed rare earth metal activated barium thioaluminate or rare earth activated magnesium thioaluminate, but instead teaches SrS:Ce or ZnS:Mn phosphors, both materials having different properties than the claimed blue light emitting phosphor. Takahashi includes the use of fluoride compounds as only one option in an extensive laundry list of possible insulating layer materials, but provides no teaching as to how to choose among the suggested materials. Further, the reference does not teach annealing or the use of annealing

temperatures to control the effect of the insulating layer on luminosity. Without a teaching (1) regarding annealing, (2) to use a rare earth activated barium thioaluminate or magnesium barium thioaluminate blue light emitting phosphor, and (3) to use a fluoride-containing insulating layer material in direct contact with the phosphor layer such that it infuses the phosphor layer, one cannot just assume that the fluoride will infuse the phosphor to form a laminate, and that no adverse effect on luminosity will be experienced.

The Examiner cites Yano for its teaching that of a barium thioaluminate phosphor. Because Yano also discloses the use of SrS:Ce, and because Yano discloses a similar listing of insulating materials, the Examiner assumes that the any insulating material from Takahashi may be substituted in the teaching of Yano. This position, however, is in error.

### **Why the Reference Combination Fails**

The Examiner assumes that SrS:Ce phosphor and BaAl<sub>2</sub>S<sub>4</sub>:Eu are interchangeable phosphors and that the insulating layers of the references are therefore also interchangeable, thus arriving at a combination of a fluoride-containing insulating layer with the claimed BaAl<sub>2</sub>S<sub>4</sub>:Eu phosphor. One skilled in the art of chemical thermodynamics and chemical kinetics of inorganic materials would know that the reactivity of a fluoride in contact with strontium sulfide (Takahashi) is in no way predictive of the reaction of a fluoride with BaAl<sub>2</sub>S<sub>4</sub>:Eu (neither reference). For the fluoride to be useful in preserving the luminance of a BaAl<sub>2</sub>S<sub>4</sub>:Eu phosphor material, it must diffuse into the crystal structure of the phosphor material without causing decomposition of the phosphor material. This is well understood by those skilled in the art of phosphor materials. Most commonly, if chemical reactions involving fluorides take place they result in destruction of the integrity and crystal structure of the reactants.

BaAl<sub>2</sub>S<sub>4</sub>:Eu and SrS:Ce are completely different compounds with unrelated thermodynamic properties and with different chemical kinetics. Thus they are not functionally or chemically equivalent. Therefore, an understanding of the behavior of the materials of Takahashi, even in view of the teaching of Yano, cannot make obvious the present invention. In fact, Takahashi infers that the fluoride layer in contact with his phosphor materials remains as a distinct layer and therefore does not react substantially

with the phosphor layer, contrary to the claims of the present invention. The fact that SrS:Ce and BaAl<sub>2</sub>S<sub>4</sub>:Eu are both blue light emitters is irrelevant in terms of predicting the chemical properties of these materials. The color of the emission is a property of the activator species and its immediate atomic-scale crystal environment and is not a bulk property of the host or base composition of the phosphor. The use of BaAl<sub>2</sub>S<sub>4</sub>:Eu in an electroluminescent device, and the effect of having a fluoride-containing insulating layer directly adjacent such phosphor layer, cannot be predicted from the use of a fluoride layer with SrS:Ce. In support of this position Applicants point out that Yano fails to include any fluoride containing insulating materials in its listing as cited by the Examiner.

In addition to the foregoing, the phosphor annealing temperature of the BaAl<sub>2</sub>S<sub>4</sub>:Eu phosphor material can be in the range of 400°C to 800°C. However, Yano does not teach the relationship between the luminance of the device and the annealing temperature. The benefit of the present invention is to lower the annealing temperature without lowering the realizable luminance, i.e., *the invention provides a means to use BaAl<sub>2</sub>S<sub>4</sub>:Eu as a phosphor in an electroluminescent device by enabling its annealing at a temperature that is compatible with the formation of the rest of the device.* The benefit of the invention is clearly shown by a comparison between Example 1 in the subject Specification, describing an electroluminescent device containing the improvement of the invention (including the aluminum fluoride layer adjacent the barium thioaluminate phosphor), and Examples 2 and 3, describing similar devices having the phosphor layer annealed at temperatures of 600°C and 700°C, respectively, that do not have the improvement of the invention (**not** including the aluminum fluoride layer adjacent the barium thioaluminate phosphor). The device of Example 1 with the phosphor annealed at 600°C and the device of example 3 with the phosphor annealed at 700°C have acceptable luminance and color coordinates, whereas the device of example 2 with the phosphor annealed at 600°C does not. The foregoing clearly demonstrates the lesser performance of prior art devices that fail to include a fluoride layer in keeping with the invention.

Even if the reactivity of BaAl<sub>2</sub>S<sub>4</sub>:Eu and a fluoride layer could be anticipated by Takahashi in view of Yano, one skilled in the art would have no basis upon reading the cited art to determine if the reaction of the fluoride layer with the BaAl<sub>2</sub>S<sub>4</sub>:Eu phosphor

layer would lower the required crystallization or annealing temperature for the phosphor layer, which is the benefit of the present invention . This is also a question of chemical thermodynamics and kinetics for which there is no available literature data that could be used to predict such an effect.

Based on the foregoing, Applicants would point out that a fair reading of the references would not lead one to combine them in an effort to achieve the claimed structure. First, neither reference seeks to enhance performance by using a structure that can be annealed at a lower temperature and yet maintain or better the luminosity of the device. However, giving the combination all possible weight, it would at best lead one to form a phosphor component including barium thioaluminate and an insulating layer chosen from those set forth at column 7 of the Yano reference, which does not include any fluoride-containing materials, as those listed are the insulating layers of choice for this phosphor thin film at the time of this reference teaching. Takahashi provide a long list of potential insulating materials, however, they fail to provide any teaching as to how to select from among those listed. They exemplify, as their preferred embodiments, the use of AlN and SiO<sub>2</sub>, but include Ta<sub>2</sub>O<sub>5</sub>. Yano also provides a listing, but this listing fails to even include fluoride compounds, and Yano's insulating layer of choice is Ta<sub>2</sub>O<sub>5</sub>, which is also disclosed by Takahashi. Based on the Examiner's reasoning, the combination that would be made from the combined teachings is the use of Ta<sub>2</sub>O<sub>5</sub> as an insulating layer for BaAl<sub>2</sub>S<sub>4</sub>:Eu, and this combination would yet lack any teaching regarding annealing temperature.

It is further noted that, as claimed, the inclusion of the fluoride-containing layer(s) in direct contact with the phosphor has an unexpected and advantageous effect on the resulting laminate, both in terms of allowing the laminate to be deposited on a glass substrate, which allows for annealing temperatures well below those necessary for other such laminates thus enhancing production capabilities, as well as in the performance of the resulting phosphor laminate, which as compared to other non-fluorine containing phosphor laminates has enhanced performance. See figures and text of the subject application.

More specifically, the invention provides a phosphor structure comprising a laminate of a rare earth metal activated barium thioaluminate or rare earth metal

activated magnesium barium thioaluminate having a fluoride layer directly adjacent a top and/or bottom of the phosphor layer (see Figure 1, reference numbers 20/22), where some of the fluoride layer is infused into the phosphor layer such that annealing of the phosphor laminate can take place at lower temperatures with no decrease in luminance. The fluoride as infused therein acts to reduce the annealing temperature required to realize adequate phosphor luminance.

### **Summary**

For at least the foregoing reasons, the *prima facie* case of obviousness is shown to fail. Specifically, it has been shown above that each reference alone fails to teach the claimed invention. Further, any combination of the cited references continues to fall short of teaching the claimed invention. Because neither reference includes a teaching or suggestion to the specific use of a fluoride-containing layer on the top and/or bottom of a blue light emitting phosphor layer, the combination cannot fairly be said to teach the claimed invention. Neither reference provides a guide as to how to select fluoride as the infusing material, nor that it must be placed directly adjacent the top and/or bottom surface(s) of the phosphor layer. Because the references each fail to appreciate the advantage to be gained by such a structure, neither reference alone, nor the references taken together, even in the best light, teach the capability to anneal at lower temperatures, and the performance advantages gained by allowing the fluoride to infuse the phosphor layer at this annealing temperature. Absent the use of the subject application as a blue print for achieving the invention claimed, one skilled in the art would not look to these references for assistance, and even with this reference combination that teaching remains absent.

## CONCLUSION

For the reasons detailed above, it is submitted all remaining claims (Claims 1, 3-6, 8-28 and 46-48) are distinguished over the cited art and are now in condition for allowance. An early notice to that effect is therefore earnestly solicited.

Remaining Claims, as delineated below:

(1) FOR	(2) CLAIMS REMAINING AFTER AMENDMENT LESS HIGHEST NUMBER PREVIOUSLY PAID FOR	(3) NUMBER EXTRA
TOTAL CLAIMS	29	- 39 = 0
INDEPENDENT CLAIMS	3	- 3 = 0

This is an authorization under 37 CFR 1.136(a)(3) to treat any concurrent or future reply, requiring a petition for extension of time, as incorporating a petition for the appropriate extension of time. A One-Month Extension of Time is being filed concurrently herewith.

The fees for the one-month extension of time are being charged to a Credit Card via the EFS Web. The Commissioner is hereby authorized to charge any underpayment in filing or prosecution fees which may be required, under 37 CFR 1.16, 1.17, and 1.21 (but not 1.18), or to credit any overpayment, to Deposit Account 06-0308.

In the event the Examiner considers personal contact advantageous to the disposition of this case, he/she is hereby authorized to call Mark S. Svat, at Telephone Number (216) 861-5582.

Respectfully submitted,

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